# Results

## Site Selection

Based on the MD-DNR SAV Restoration Targeting System, five sites in the lower Patuxent River, Parrans Hollow (38° 24.714’ N 76° 31.649’ W), Jefferson Patterson Park (38° 24.438’ N 76° 31.268’ W), Myrtle Point (38° 19.755’ N 76° 29.493’ W), Hungerford Creek (38° 20.975’ N 76° 28.317’ W), and Solomons Island (38° 18.898’ N 76° 27.252’ W) were identified as suitable habitats for eelgrass recolonization.

## Seed Collection

2003: Reproductive shoots from healthy eelgrass beds containing mature seeds were collected manually in Tangier Sound. Harvesting took place on May 20, 23, and 27-30 and yielded 2.3 million seeds, 250,000 of which were viable for broadcast (Table 4).

2004: A mechanical harvest boat was utilized to increase the efficiency and amount of reproductive material collected. From May 24 to June 4, 2004, seeds were collected from donor beds in the Little Annemessex River. In nine cutting days the mechanical harvester collected reproductive material resulting in approximately 71.92 L of eelgrass seeds. The portion of reproductive material transported to Piney Point for seed extraction yielded 15.12 million seeds (Table 4). After the seed processing and storage process was complete, 7% of the collected seeds (or 1,058,400 seeds) were viable for broadcast.

2005: Reproductive material was harvested from the Little Annemessex River and the mouth of Acre Creek (Big Annemessex River) from May 23 to June 8, 2005. The harvest machine collected approximately 109.5 L of eelgrass seeds from 21.6 acres of eelgrass beds. Seed count estimates were made after all of the seeds had fallen from the reproductive shoots and had been separated from the decaying reproductive material. Replicate 2 ml samples of seed material were analyzed for the number of viable seeds of the total number of seeds. The total number of seeds harvested was calculated as the sum of the number of seeds per ml (113/ml) and the total volume of seeds collected (109.5 L). Based on this calculation, the portion of reproductive material transported to Piney Point for seed extraction yielded 12,373,500 seeds (Table 4). An estimate of the number of viable seeds was also determined as the sum of the number of viable seeds (68 viable seeds/ml) and the total volume of seeds. Using this calculation, there were an estimated 7,446,000 viable seeds, 60% of the total number of seeds collected, after processing was through. After storage of the seeds throughout the summer, there were a total of 2,527,000 viable seeds (20% of the total number of seeds collected).

In order to estimate the number of seeds disbursed through the seed bag method in 2004 seeds were enumerated in four 1 L replicate subsamples of reproductive material shortly after collection, but before seed bags were constructed. Because a known amount of seed material was used to fill each seed bag, the number of seeds per liter, the number of seeds/seed bag, and the number of seed bags /plot could be used to calculate the total number of seeds dispersed at each location using this method (number of seeds/acre reported in Table 1).

**Test Plantings**

Test plantings were planted in fall of 2004 to ensure that areas identified by the site selection model would support growth of eelgrass. Adult eelgrass plants were transplanted into three 1 $m^2$ test plots located adjacent to seed broadcast or seed bag areas. Test plantings occurred on November 13, 2003, November 18, 2004, and November 1, 2005. A density of 64 adult plants per $m^2$ was used for each test plot. When the test plots planted in 2004 were surveyed in the 2005, 77% of the plants among the three test plots had survived when surveyed in May, but only 15% of these plants persisted in July at Parrans Hollow (Figure 9 and Table 5). This resulted in a 77% initial planting success rate. In July, an average of 7 plants persisted, only 15% of the initial plants that succeeded. No plants were present at any of the three test plots here in November. At Hungerford Creek, 44% of the plants had survived when surveyed in May, dropping to 25% persistence in July. No plants were present at any of the three test plots in November. At Solomons Island, 82% of the initial plants survived until May, but only 4% of these plants persisted until July. No plants were present at any of the three test plot locations in November.

**Eelgrass Seeding**

*Patuxent River Seeding Details by Year*

23.75 acres at five restoration locations in the Patuxent River have been seeded since commencement of this project (Figure 10). In October of 2003, six 0.5 acre plots were seeded by broadcasting seeds manually at Jefferson Patterson Park (Table 2). In May 2004, 381 spring seed bags were deployed containing 1.91 million seeds and covering

14.5 acres (Table 1). In October 2004, 0.75 acres were seeded by broadcasting 112,500 seeds mechanically (Table 3). Seeding also took place in August of 2005 when 368,500 seeds covering 5.5 acres were broadcast mechanically (Table 3). The remainder of the results reported here are the data from the 2004 spring seed bag and fall seed broadcast efforts.

*Seeding Results by Restoration Location (2005 surveys of 2004 seeding efforts)*

***Parrans Hollow***

In 2004, a total of 887,500 eelgrass seeds were dispersed at Parrans Hollow covering 6.25 acres at three locations (Tables 2 and 3, Figure 11). In May, spring seed bags were deployed at two adjacent areas, one 5 acres and the other 1 acre, with 605,000 and 245,000 seeds, respectively (Table 6). During the fall seed broadcast (October), a total of 37,500 seeds covering 0.25 acres were broadcast. All 2004 seeding areas were surveyed in the spring and summer of 2005.

*2004 Seedling Survival Data*

- Fall Seed Broadcast: No eelgrass seedlings were observed in the 2004 fall seed broadcast site during the May, July, or November 2005 surveys.
- Spring Seed Bags: A total of 120 and 104 seedlings per acre were observed at 2004 spring seed bag sites 1 and 2 when surveyed in May 2005, respectively (Figure 16A and Table 7) yielding an initial planting success of 0.05 and 0.09%, respectively at these sites (Figure 16B and Table 6).
- Other Observations: During the May 2005 survey, divers noted the presence of both *Zannichellia palustris* (horned pondweed) and *Ruppia maritima* (widgeon

grass) within the test plot area adjacent to the restoration locations. In addition, there were a number of eelgrass plants flowering just outside the test plot areas. High fouling rates were evident on the plants present in the test plots. In July 2005, the adult plants in the test plots were heavily fouled and very short, but appeared green and healthy nonetheless. Horned pondweed and widgeon grass were both observed by divers during transects. Two shoots of eelgrass were observed outside of the transect area. Clam dredge scars were prevalent throughout transects across the planting sites during both the May and July 2005 surveys.

***Jefferson Patterson Park***

A total of 501,000 eelgrass seeds have been dispersed at Jefferson Patterson Park covering 7 acres of bottom (Table 5). Restoration activities here have included fall seed broadcast in 2003, spring seed bag deployment in 2004, and fall seed broadcast in 2005 (Figure 12 and Table 5). In 2003, 300,000 seeds were broadcast into six 0.5-acre circles. In 2004, 150,000 seeds were broadcast over 1 acre using spring seed bags. In 2005, the fall seed broadcast resulted in 201,000 seeds being broadcast over 3 acres (Table 6).

*2004 Seedling Survival Data*

- Fall Seed Broadcast: No eelgrass seedlings were observed at the 2003 fall seed broadcast site during the May, June, or November 2005 surveys.
- Spring Seed Bags: A total of 155 seedlings per acre were observed at the 2004 spring seed bag site when surveyed in May 2005 (Figure 16A and Table 7) yielding an initial planting success of 0.10% (Figure 16B and Table 6).

- Other Observations: During the May 2005 survey, divers noted a high density of horned pondweed and fewer widgeon grass plants along transects of the planted area. In July and November 2005, divers noted a completely bare bottom during all transects at this location.

*2005 Activity* The 3 acre fall seed broadcast area will be surveyed in the spring of 2006 to determine the success of the fall seed broadcast effort that took place in October 2005.

***Hungerford Creek***

A total of 171,500 eelgrass seeds have been dispersed at Hungerford Creek covering 2.25 acres of bottom (Table 5). Restoration activities here included fall seed broadcast in 2004 and 2005 (Figure 13 and Table 5). A total of 37,500 seeds covering 0.25 acres and 134,000 seeds covering 2 acres were broadcast in October 2004 and August 2005, respectively (Table 6).

*2004 Seedling Survival Data*

- Fall Seed Broadcast: No eelgrass seedlings were observed at the 2004 fall seed broadcast area during the May, July, or November 2005 surveys.
- Other Observations: During the May 2005 survey, divers noted a thriving population of horned pondweed as well as a prominent filamentous algae cover, both of which made it extremely difficult to distinguish eelgrass seedlings at this location. Flowers were present on half of the eelgrass plants located in the test plot. In addition, there were a number of eelgrass flowering plants just outside the test plot areas. In July 2005, the adult plants in the test plots were heavily fouled and very short. When divers attempted to wipe the epiphytes from the leaves,

leaves were brittle enough that they broke away from the main plant. Evidence of worms (unidentified species) and cownose rays (*Rhinoptera bonasus*) were prevalent throughout transects across the planting sites. In November 2005, divers noted a completely bare bottom during all transects at this location.

*2005 Activity* The 2 acre fall seed broadcast area will be surveyed in the spring of 2006 to determine the success of the seed broadcast effort that took place in October 2005.

***Myrtle Point***

A total of 333,500 eelgrass seeds have been dispersed at Myrtle Point covering 3 acres of bottom (Table 5). Restoration activities here included one spring seed bag deployment in 2004 and one fall seed broadcast site in 2005 (Figure 14 and Table 5). In May 2004, spring seed bags containing roughly 300,000 seeds were deployed covering 2.5 acres. In 2005, the fall seed broadcast resulted in 33,500 seeds being broadcast over 0.5 acres (Table 6).

*2004 Seedling Survival Data*

- Spring Seed Bags: A total of 32 seedlings per acre were observed at the 2004 spring seed bag site when surveyed in May 2005 (Figure 16A and Table 7) yielding an initial planting success at this site of 0.03% (Figure 16B).
- Other Observations: During the May 2005 survey, divers noted an extremely strong current moving across the planted area. In July and November 2005, divers noted a completely bare bottom during all transects at this location.

*2005 Activity* The 0.5 acre fall seed broadcast area will be surveyed in the spring of 2006 to determine the success of the seed broadcast effort that took place in October 2005.

***Solomons Island***

A total of 642,500 eelgrass seeds have been dispersed at Solomons Island covering 5.25 acres of bottom (Table 5). In May 2004, spring seed bags containing roughly 605,000 seeds were deployed covering 5 acres (Figure 15 & Table 6). In October 2004, the fall seed broadcast resulted in 37,500 seeds being broadcast over 0.25 acres (Table 5).

*2004 Seedling Survival Data*

- Spring Seed Bags: No eelgrass seedlings were observed at the 2004 spring seed bag (Table 7) or fall seed broadcast areas during the May, July, or November 2005 surveys.
- During the May 2005survey, divers noted epiphytic growth on the adult test plot plants. Little to no vegetation was present throughout transects, and a distinct ripple pattern was evident in the sediment at the bottom. In July 2005, divers noted a completely bare bottom during all transects at this location. During all of the surveys (May, July, November 2005), divers noted an extremely strong current moving across the planted area.

**Water Quality**

The SAV Strategy calls not only for large-scale SAV restoration projects, but also for coincident assessment of the associated habitat conditions in order to evaluate reasons for success or failure and, in turn, improve the likelihood of success of future projects. In keeping with this requirement of the Strategy, spatially and temporally intensive water quality monitoring was conducted during 2003, 2004, and 2005.

***Continuous Monitoring (temporally intensive monitoring)***

Two continuous monitoring (YSI 6600 EDS) stations were located on the Patuxent River prior to and during restoration (2003-2005) to provide temporally intensive habitat assessments to complement the monthly water quality mapping. The first monitoring station was located at the Pin Oak Farm (38° 24.528' N 76° 31.308' W) near the Jefferson Patterson Park restoration site (MLW, 1.2 m) and the second monitoring station was at the Chesapeake Biological Laboratory (CBL) dock (38° 19.002' N 76° 27.156' W) near the Solomons Island restoration site (MLW, 2.4 m). Both meters were located at a constant depth of approximately one meter below the surface of the water

*CBL* Figure 17 includes turbidity and temperature data at the CBL continuous monitoring station for 2003, 2004, and 2005. DATAFLOW and Patuxent River mainstem cruises are marked on the graphs. The red line on the graph indicates a turbidity of 5.38, the water quality target for SAV in the Patuxent River that corresponds to 22% light to a depth of 1 m. On the 2005 panel the dates of DNR's SCUBA surveys are also marked (May 17, July 26, and November 4).

Turbidity was lower in 2003 than 2004 and 2005, and only exceeded the 5.38 NTU limit 4.5% of the year (Table 8). Turbidity during the SAV growing season (March-October, where data available) exceeded the limit 4.6% of the time. Increased turbidity was seen from March until October 2004 with peaks between May and July. Turbidity levels exceeded limits 18.0% of the year and 20.1% of the SAV growing season. Elevated

turbidity levels occurred throughout the year in 2005. The 2005 continuous monitor dataset did not start until April 6 and ended Oct 31 therefore the full year dataset available is identical to the SAV growing season dataset. Turbidity exceeded limits 13.2% of the year/SAV growing season. Between the May 17 and July 26 survey dates, turbidity exceeded the 5.38 NTU limit 24.8% of the time.

Looking at potential temperature effects during this study, thresholds for eelgrass survival of 25$^{o}$C and 30$^{o}$C were examined (Table 8). According to the continuous monitor data temperatures exceeded 25$^{o}$C for some period of time in every year, with the highest percentage being in 2005 (more than in 2003 and 2004), nearly 50% of the time. Temperature did not exceed 30$^{o}$C during 2003 or 2004. Temperature values exceeded 30$^{o}$C 1.6% of the time during the SAV growing season and 0.3% of the time between surveys in 2005.

*Pin Oak Farm* Figure 18 includes turbidity and temperature data at the Pin Oak continuous monitoring station for 2003, 2004, and 2005. DATAFLOW and Patuxent River mainstem cruises are marked on the graphs. The red line on the graph indicates an NTU of 5.38, the water quality target for SAV in the Patuxent River that corresponds to 22% light to a depth of 1 m. On the 2005 panel the dates of DNR's SCUBA surveys are also marked (May 17, July 26, and November 4).

Turbidity values were higher at the Pin Oak station than the CBL station across all three years. Despite being lower in 2003 than 2004 and 2005, turbidity exceeded the 5.38

NTU limit 41.9% of the year (Table 8). Turbidity during the SAV growing season (March-October, where data available) exceeded the limit 45.6% of the time. Increased turbidity was seen throughout the year in 2004. Turbidity levels exceeded limits 64.6% of the year and 70.9% of the SAV growing season. Elevated turbidity levels occurred throughout the year again in 2005. The 2005 continuous monitor dataset did not commence until April 6 and ended Oct 31 therefore the full year dataset available is identical to the SAV growing season dataset. Turbidity exceeded limits 54.7% of the year/SAV growing season. Between the May 17 and July 26 survey dates, turbidity exceeded the 5.38 NTU limit 62.7% of the time.

At the Pin Oak station, temperatures were above 25$^{o}$C over 60% of the year and growing season in 2003, dropped slightly in 2004 (38.2 and 42.8% during the year and growing season, respectively), and were high again in 2005 exceeding 25$^{o}$C over 50% of the time for the entire dataset/growing season and 61.3% of the time between the May 17 and July 26 surveys (Table 8). Temperature exceeded 30$^{o}$C 3.7% of the year and 4.0% of the SAV growing season in 2003. Temperature only exceeded 30$^{o}$C 0.5% of the year and 0.6% of the SAV growing season during 2004. In 2005, temperature values exceeded 30$^{o}$C 8.0% of the time during the SAV growing season and 9.1% of the time between surveys.

Fluorescence (Chla) was another parameter monitored by the continuous monitor stations. Correlation values were determined between turbidity and Chla values from the 2003, 2004, and 2005 continuous monitor datasets. At the CBL station in 2003 the

Pearson correlation coefficient was 0.5 ($P < 0.0001$, $N = 11905$). The 2004 and 2005 correlations yielded coefficients of 0.03 ($P < 0.0001$, $N = 25876$) and 0.14 ($P < 0.0001$, $N = 17423$), respectively. At the Pin Oak station in 2003 the correlation coefficient was 0.48 ($P < 0.0001$, $N = 10637$). The 2004 and 2005 correlations yielded coefficients of 0.03 ($P < 0.0001$, $N = 25323$) and 0.14 ($P < 0.0001$, $N = 16564$), respectively.

***DATAFLOW (spatially intensive monitoring)***

Spatially intensive water quality monitoring (water quality mapping) was conducted monthly throughout the eelgrass-growing season (March – November) in the lower portion of the river utilizing MD-DNR DATAFLOW systems. Turbidity data from the Patuxent River DATAFLOW cruises were complied and analyzed for 2003, 2004, and 2005.

DATAFLOW cruises were conducted and turbidity data analyzed from April through October 2003 (Figure 19), March through November 2004 (Figure 20), and April through September 2005 (Figure 21). In 2003, turbidity peaked between May and June throughout the river (Figure 19). Despite remaining high in the upper reaches of the river until July, turbidity decreased in the areas where restoration was being conducted in July. High turbidity events seemed to be spatially patchy in 2004 (Figure 20). In 2005, peaks in turbidity were evident in the upper river from April through July (Figure 21). Turbidity in the lower river near the restoration locations appears to have remained constant between 2.5 and 5 NTU's until August when it decreased.

Secchi depth (Figure 22), TSS (Figure 23), and temperature (Figure 24) values for 2003, 2004, and 2005 (secchi depth and temperature only) were compared to the range and mean of available data from 1985 until 2002 at Saint Leonard, Point Patience, and Drum Point. Water clarity values for 2003, 2004, and 2005 are close to the mean, and do not fall outside of the range when compared to the 20-year record available at these three stations on the Patuxent River. In 2005, temperatures were uncharacteristically high, falling outside of the 20-year temperature range for the months of August and September at each of the three stations, and October at Point Patience.

**Cost Comparison and Survival Calculations**

At the conclusion of the first year of restoration, several cost calculations were made based on the planting results. To determine the financial investment made per seed dispersed, the total cost of the particular method was divided by the total number of viable seeds dispersed using that method.

The cost per seed put out on the Patuxent River (ignoring survival) $0.02 for the spring seed bag method and $0.34 for the fall seed broadcast. The total cost for restoring one acre was determined by multiplying the cost per seed by the specified seeding density (200,000 seeds/acre for both methods). The cost for restoring one acre was determined to be $4,473 for the spring seed bag method and $67,085 for the fall seed broadcast method.

The recruitment success of each method was determined by dividing the total number of seeds dispersed by the number of successfully recruited plants. The spring seed bag

method yielded 874 seedlings across all spring seed bag sites locations in May 2005. A total of 1,910,000 seeds were dispersed using this method. Therefore the overall recruitment success for the spring seed bag method was 0.05% after 11 months. However, none of these plants survived the summer. The fall seed broadcast method did not yield any seedlings. Therefore, regardless of the number of seeds broadcast this way; the recruitment success of that method was 0.0%.

The total cost for each method was divided by the total number of successfully recruited seedlings to determine cost per successfully recruited seedling between the spring seed bag and fall seed dispersal methods. Each seedling (874) successfully recruited using the spring seed bag method cost $11.15. This figure could not be calculated for the fall seed broadcast method due to the lack of successful recruitment.

For the purpose of cost comparison between methods, site selection, monitoring, and certain salary costs were not included. A more comprehensive cost analysis of the above-cited figures including site selection, monitoring and salary costs will be included in the final project report.

Despite the low seedling survival, much useful information came out of this project which will be discussed below.

**Project Website**

In addition to field work and other requirements of this project, Maryland Department of Natural Resources created an online website resource specific to this project (http://www.dnr.state.md.us/bay/sav/restoration/pax_gen_info.asp). Included in this webpage is background information about this project, a timeline of major project activities, maps depicting restoration locations, explanation of project methods, seeding details, and photographs of the various stages of this project. This and subsequent reports will be posted on the website in PDF format once complete.

According to a WebTrends report produced by MD-DNR Information Technology Services, 4,619 visitors have logged a total of 26,987 successful hits, an average of 146 hits per day since it was posted in late July. Visitors spent an average of 11 minutes navigating the website. The Patuxent River Eelgrass Restoration Project page (http://www.dnr.state.md.us/bay/sav/restoration/pax_gen_info.asp) ranked as the third most popular webpage visited from the restoration homepage (address above).